

# **Combustion Module-2 Preparations Completed for SPACEHAB Mission Including the Addition of a New Major Experiment**

The Combustion Module-1 (CM-1) was a large, state-of-the-art space shuttle Spacelab facility that was designed, built, and operated on STS-83 and STS-94 by a team from the NASA Glenn Research Center composed of civil servants and local support contractors (Analex and Zin Technologies). CM-1 accomplished the incredible task of providing a safe environment to support flammable and toxic gases while providing a suite of diagnostics for science measurements more extensive than any prior shuttle experiment (or anything since). Finally, CM-1 proved that multiple science investigations can be accommodated in one facility, a crucial step for Glenn's Fluids and Combustion Facility developed for the International Space Station. However, the story does not end with CM-1. In 1998, CM-2 was authorized to take the CM-1 accomplishments a big step further by completing three major steps:

1. Converting the entire experiment to operate in a SPACEHAB module
2. Conducting an extensive hardware refurbishment and upgrading diagnostics (e.g., cameras, gas chromatograph, and numerous sensors)
3. Adding a new, completely different combustion experiment.

CM-2 has successfully completed these new tasks using only one-eighth the resources of CM-1.

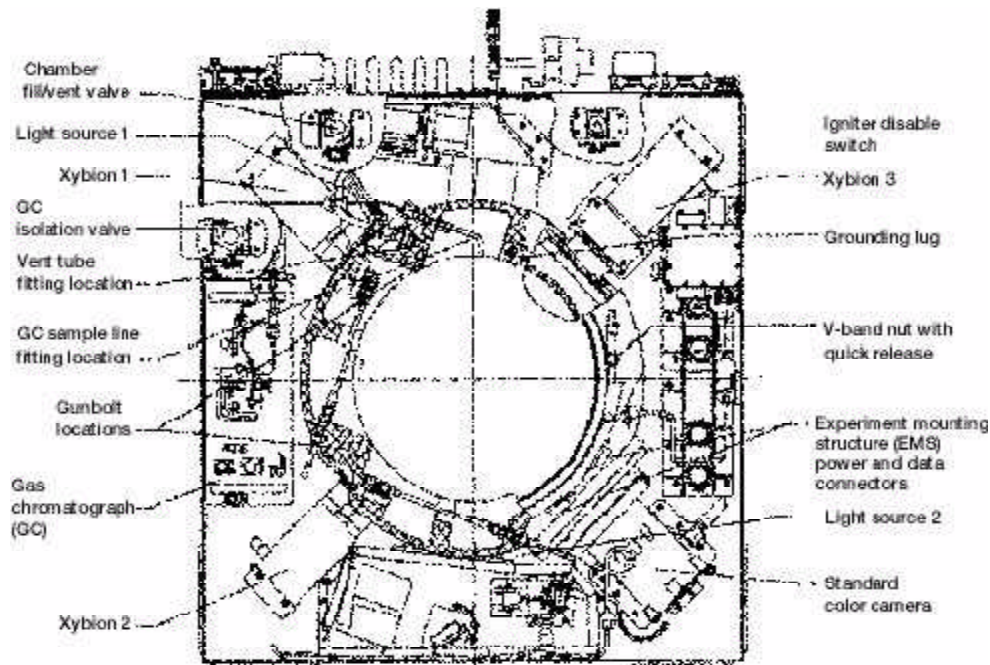
NASA funds combustion research with practical relevance in mind: to improve fuel efficiency, health (reduce pollutants), and fire safety both on Earth and in space. The overall purpose of CM-2 is to host three major combustion experiments:

- Laminar Soot Processes-2 (LSP-2)
- Structure of Flame Balls at Low Lewis-number-2 (SOFBALL-2)
- Water Mist Fire Suppression Experiment (Mist)



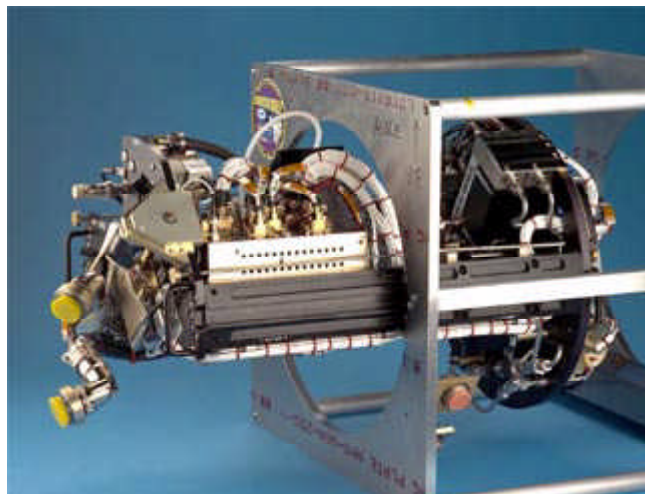
*Combustion Module-2 flight system in SPACEHAB racks.*

To accommodate just LSP-2 and SOFBALL-2, the CM-2 team needed to convert the facility from Spacelab to SPACEHAB and to conduct an extensive refurbishment and requalification for flight safety and science needs. The SPACEHAB conversion impacted every engineering interface including physical layout, structures (dynamics and stress), and thermal, electrical, data, software, and safety controls. For example, given the higher launch loads and the fact that CM-1 was qualified for only one flight, a special structural qualification approach was developed using a combination of low-level rack system vibration testing and analysis to minimize the risk to the CM-2 hardware. As in CM-1, flight rack integration was accomplished at Glenn, saving time and risk for the conversion process. The final flight assembly is shown in this photograph. Internal to CM-2, there was also a significant effort including extensive pressure system refurbishment and retesting as well as upgrades and/or fixes to most diagnostics based on CM-1 experience. For example, six of the seven CM-2 cameras were modified in some way to improve performance. The schematic shows the core of CM-2, the experiment package, with the Mist experiment diagnostics highlighted.



*Combustion Module-2 experiment package diagnostics for Mist.*

The third accomplishment of CM-2 is the successful integration of a new experiment, Mist. Unlike LSP and SOFBALL, Mist is a commercially sponsored experiment through the Commercial Center for Applications of Combustion in Space (CCACS). Also, unlike LSP and SOFBALL, the Mist chamber insert, or experiment mounting structure, was developed and built by CCACS, with the Glenn team serving as consultants (see the final photograph). Mist was able to utilize the existing CM-2 chamber, cameras, gas chromatograph, data processing and storage, and experiment control computers without any modifications to the CM-2 hardware. Unique software and system integration activities were accomplished by the CM-2 team in partnership with the Mist CCACS personnel. This partnership provided further evidence to validate the multiuser approach technically, and provided a role model for the Fluids and Combustion Facility to use during future cooperative efforts on the International Space Station.



*Water Mist Fire Suppression Experiment mounting structure.*

The CM-2 preflight efforts culminated at the end of fiscal year 2000 with the completion of a successful verification program and shipment to the launch site for SPACEHAB integration and testing. CM-2 is part of the SPACEHAB Research Double Module planned to be flown on STS-107.

**Find out more about microgravity combustion research at Glenn**

(<http://exploration.grc.nasa.gov/combustion/>)

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**Special recognition:** LSP-1 and SOFBALL-1 research results published extensively including the acclaimed Special Issue on Microgravity Combustion, in the Combustion and Flame Journal, published by the Combustion Institute.